

Homework 9 : 5.16, 5.17, 5.24, 6.1, 6.2.

5.16 a) ~~yes~~. I mean true.

b) false. Pressure cooker increases external pressure, thus increases boiling point.

c) false K_f is a property of solvent.

$$T_f^\circ - T_f = K_f m \quad \leftarrow \text{depends on solvent.}$$

d) true $P_A = X_A P_A^\circ$
 $P_A^\circ - P_A = (1 - X_A) P_A^\circ \quad \nearrow \quad \frac{P_A^\circ - P_A}{P_A^\circ} = X_B$

e) false $F = C - P + 2.$

$$C = 2$$

NaCl and water

$$P = 2$$

NaCl(s) and NaCl(aq).

f) false chemical potentials are already the same.

5.17 a) $P_A = X_A P_A^\circ$

$P_A^\circ - P_A = X_B P_A^\circ$

$$\text{mole}_m = \frac{54.66 \text{ g}}{182.2 \frac{\text{g}}{\text{mol}}}$$

$$= 0.3 \text{ mole}$$

$$\text{mole}_{\text{H}_2\text{O}} = \frac{100 \text{ g}}{18 \frac{\text{g}}{\text{mol}}}$$

$$= 55.56 \text{ mole}$$

$$\# P_{H_2O}^{\circ} - P_{H_2O} = X_m \cdot P_{H_2O}^{\circ} = \left(\frac{0.3}{55.56 + 0.3} \right) \cdot 17.54 = \underline{\underline{0.094 \text{ Torr}}}$$

$$b) X_{H_2O} = 0.9946$$

$$P_A = a P_A^{\circ} = \gamma X_A P_A^{\circ}$$

$$\frac{P_A^{\circ} - P_A}{P_A^{\circ}} = 1 - \gamma X_A$$

$$\gamma = 1 - \frac{P_A^{\circ} - P_A}{P_A^{\circ}} = 1 - \frac{P_{H_2O}^{\circ} - P_{H_2O}}{P_{H_2O}^{\circ}} \approx \overset{0.9947}{\underline{\underline{1}}}$$

$$c) \pi = CRT = 0.3 \cdot (0.08206) (293K) = \underline{\underline{7.2 \text{ atm}}}$$

$$\pi = -\frac{RT \ln a_A}{V_A} = -(0.08206) (293K) \ln (0.9947)$$

$$= \underline{\underline{7.1 \text{ atm}}}$$

$$5.24 \quad 22 \text{ mm of } H_2O = 1.61 \text{ mmHg} = 1.61 \text{ torr}$$

$$\pi = CRT \quad c = \frac{0.002121 \text{ atm}}{0.08206 \cdot 298K} = 8.67 \times 10^{-5} M$$

In 100 mL solution, there is 8.67×10^{-6} mole.

$$\frac{\text{Total weight}}{\text{Total mole}} = \frac{0.6g}{8.67 \times 10^{-6} \text{ mole}} = \underline{\underline{6.92 \times 10^4 \frac{g}{\text{mole}}}}$$

6.1 $\sigma = 2.5 \times 10^{-10} \text{ m}$, $P = 1 \text{ atm}$, $T = 273 \text{ K}$.

$$a) \sqrt{\langle v^2 \rangle} = \sqrt{\frac{3RT}{M}} = \left(\frac{3 \cdot 8.314 \cdot 273 \text{ K}}{\frac{2}{1000} \text{ kg}} \right)^{\frac{1}{2}} = \underline{\underline{1.845 \times 10^3 \frac{\text{m}}{\text{s}}}}$$

$$b) \frac{3}{2} RT = \underline{\underline{3.4 \text{ kJ/mol}}}$$

$$c) PV = nRT \quad \frac{n}{V} = \frac{P}{k_B T} \quad \rho = \frac{101325 \text{ Pascal}}{1.38 \times 10^{-23} \cdot 273 \text{ K}}$$

$$\rho = 2.69 \times 10^{25} \frac{\text{molecule}}{\text{m}^3} \quad n = \rho \cdot V = 2.69 \times 10^{25} \cdot 10^{-6} \text{ m}^3$$

$$n = \underline{\underline{2.69 \times 10^{19}}} \text{ in } 1 \text{ cm}^3$$

$$d) l \equiv \lambda = \frac{\langle u \rangle}{Z} = \frac{1}{\sqrt{2} \pi \left(\frac{N}{V} \right) \sigma^2} = \frac{1}{\sqrt{2} \pi} \frac{1}{2.69 \times 10^{25}} \cdot \frac{1}{(2.5 \times 10^{-10})^2}$$

$$l = \underline{\underline{1.34 \times 10^{-7} \text{ m}}}$$

$$e) Z = \sqrt{2} \pi \cdot \frac{N}{V} \cdot \sigma^2 \langle u \rangle = \underline{\underline{1.264 \times 10^{10} \text{ s}^{-1}}}$$

$$f) Z = \frac{Z}{2} \frac{N}{V} = \frac{1.264 \times 10^{10} \text{ s}^{-1}}{2} \cdot 2.69 \times 10^{19} \text{ cm}^{-3} = \underline{\underline{1.71 \times 10^{29} \text{ s}^{-1} \text{ cm}^{-1}}}$$

$$6.2 \quad \nu = 100 \text{ MHz} = 100 \times 10^6 \text{ Hz}$$

$$\Delta E = h\nu = 6.626 \times 10^{-34} \cdot 1 \times 10^8 = \underline{\underline{6.626 \times 10^{-26} \text{ J}}}$$

$$a) \quad N_{\text{higher}} = 0 \quad N_{\text{lower}} = 1.$$

$$e^{-\frac{\Delta E}{k_B T}} = \frac{0}{1} \rightarrow \underline{\underline{T = 0}}$$

$$b) \quad \frac{N_{\text{higher}}}{N_{\text{lower}}} = 1.$$

$$e^{-\frac{\Delta E}{k_B T}} = 1$$

↓

$$\underline{\underline{T = \infty}}$$

$$c) \quad \cancel{F} \quad N_{\text{lower}} = 1.000015 \quad N_{\text{higher}}.$$

$$\frac{N_{\text{higher}}}{N_{\text{lower}}} = \frac{1}{1.000015} = e^{-\frac{\Delta E}{k_B T}}$$

$$e^{-x} = 1 - x + x^2 - \dots$$

$$\frac{1}{1.000015} = 1.5 \times 10^{-5} = \frac{\Delta E}{k_B T} - \left(\frac{\Delta E}{k_B T} \right)^2 + \dots \quad \text{neglect.}$$

$$1.5 \times 10^{-5} = \frac{0.048}{T} \quad T = \underline{\underline{320 \text{ K}}}$$

$$= \underline{\underline{47^\circ \text{C}}}$$

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